

## ARCHAEOLOGICAL PALYNOLOGY AT AZ 22822: THE PILOT STUDY

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### PURPOSE AND OBJECTIVES

Study of a collection of 32 sediment samples collected from AZ 22822 during summer, 1998, was principally undertaken to provide opportunities for students to obtain training and develop initial expertise in the skills and disciplines of archaeological pollen analysis. To fulfill course credit obligations, students were required to follow this laboratory's standard procedure for extracting pollen from samples of archaeological site context deposits (Schoenwetter 1996); to gain familiarity with the characteristic morphological features of approximately 35 pollen types that typically occur at Colorado Plateau archaeological sites; to accept responsibility for observing, identifying and tabulating approximately 200 pollen grains on microscope slides made up from the extracted fractions of the samples; to undertake self-evaluation of their activities in the latter regard and advise changes in the tabulations they considered necessary because of errors resulting from inexperience; and to perform analyses of the entire available body of palynological information with the objective of resolving problems established prior to initiation of the study.

Secondarily, the study was performed to obtain information on the potential of the deposits of this site to provide palynological records of archaeological relevance, and to determine whether or not patterned variability in the horizontal and/or vertical distribution of pollen statistics would be likely to prove valuable for future archaeological

research planned for this site and others in its environs.

It is important to realize the archaeological interests of the study were of decidedly lower priority than the educational interests, because it was the latter that guided identification of the samples upon which the study was based. Also, since archaeological interpretation of the palynological record was not the primary purpose of the effort, such interpretations as are offered here must be recognized as significantly less rigorously controlled, and potentially subject to greater error, than those which are the normal product of research undertaken at this laboratory.

## BACKGROUND TO THE RESEARCH

This research was designed around information provided by the director of the site excavation program and by a student who had participated in that work. I am informed the site is best characterized geomorphologically as a dune (or perhaps a series of superimposed and overlapping dunes) resting upon an unconformable contact with a significantly more indurated terrace deposit above the present floodplain of Chevelon Creek, close by present Chevelon Crossing. Subsurface examination has been so far limited to a systematic program of coring the site's deposits with bucket auger technology, with subsequent retention and study of the character and contents of deposits from 10cm intervals in the cores. When the pollen study was initiated, I was advised that field data suggested the site yielded evidence of at least two horizons of human occupation, and that artificial constructions, presumably pithouse dwellings, may have been excavated into the underlying terrace deposits in some parts of the site.

Given the numbers of enrolled students, the range and variety of skills and tasks expected of them, and the time-constraints imposed by classroom and semester

scheduling, I chose to limit the study to 32 samples. The geomorphological information available suggested one could reliably recognize four sorts of contexts that might yield palynologically distinctive samples: the deposits in filling excavations that may have been made into the terrace deposits prehistorically; the contact deposits lying upon the unconformable surface of the terrace, the dune deposits lying between that contact and the modern surface, and the modern surface of the site -- some of which is stabilized by vegetation and some of which is undergoing active deflation or deposition. Available archaeological information suggested one could reliably recognize two other contexts that might yield palynologically distinctive samples: deposits which had produced archaeological evidence of possibly earlier and possibly later site occupation.

Accordingly, I requested Dr. Barton to select 32 samples he had recovered for pollen study with the following distributions and rationales: 4 samples were to be submitted for study that had been collected at 0-10 cm depth in different areas of the site. If polliniferous, these might serve as proxy records of the modern pollen rain at the locale and suggest something of the degree of horizontal variability in samples with some potential for contemporaneity. They also were likely to be samples that contain well preserved pollen. 8 samples were to be submitted representing two core columns at 20cm depth intervals. Whether the pollen records of these two series were consistently alike or not, the results would suggest something of the degree of replicability among pollen records of the dune deposits, and something of the degree of vertical variability potentially expressible as a site-specific pollen sequence.

10 samples were to be submitted that represented the lower deposits in filling possible pithouse structures. In contrast to the research area generally known as

“Environmental Archaeology” (*sensu* Shackley, 1985) which seeks identification of the environmental context of archaeological records, archaeological palynology focuses on exploiting the potential of pollen analysis to resolve archaeological problems suggested by anthropological analogues and the characteristics of archaeological data. Such problems are normally best approached through analysis of pollen records that have secure, direct, association with controlled archaeological records. This group of samples offered opportunity to assess the potential for future applications of pollen study to archaeological problem orientations at this locale.

Finally, 10 samples were to be selected that would either represent the contact of the terrace and basal dune deposits or would ostensibly contain pollen deposited in direct association with artifactual materials of differing antiquity. The former sort of samples provided another opportunity to assess whether or not samples likely to have been deposited contemporaneously at different places on the site yielded comparable data. If the samples associated with artifactual materials were comparable to samples recovered from the column series, they would provide insight into the nature and timing of chronological episodes of site occupancy that were identifiable through pollen analysis.

One of the submitted samples was lost as a result of laboratory error and six were assessed as yielding insufficient pollen to provide an analysis comparable to the others. Thus the data base incorporates the pollen records of 25 samples, though more than one student often observed, identified and tabulated pollen from individual samples.

DATA BASE QUALITY

Palynological data exists in three forms. One is the variety of pollen taxa recognized, the second is the relative frequency (percentage) of each of those taxa in the pollen observed and tabulated for a sample, and the third is the absolute quantity of pollen of all types (or pollen of any given type) per unit weight or unit volume of sampled deposit. Each of these forms of data is subject to error.

Some forms of error amount simply to mistakes due to inexperience and failure to satisfactorily internalize and utilize appropriate instructions. Misidentification of pollen taxa is the most common mistake of this sort, and there is little doubt that some of the pollen types of the AZ22822 data base are mistaken diagnoses. There is also little doubt, however, that the overwhelming majority of mistaken diagnoses were recognized by the students who made them and have been eliminated from the records of observed pollen.

Other forms of error are so common to palynological research that means for recognizing them and mechanisms for reducing their effects are standard aspects of normal analyses. For example, the specific nature of the processes by which pollen is dispersed from the male organs in which it is formed to the female organ in which it fulfills its reproductive function makes it possible for pollen grains to be observed in excessive frequency values. Such "local overrepresentation" is classically identified as information which would lead to interpretive error, so should be adjusted in a way which would reduce this effect. Depending on the character and purpose of the analysis, for example, one might exclude locally overrepresented pollen frequency values from the analysis, or substitute the average pollen frequency value for that taxon for the overrepresented frequency value.

Copies of the observation forms filled out by the students have been submitted with this report, as well as a tabulation of all observations and other information (e.g. the pollen concentration/ cubic centimeter of processed sample). The tabulation should be considered a “raw” data base for interpretation. Taking the degree of experience of the observers into consideration, however, as well as the likelihood for confusion amongst different pollen types, the opportunities provided by the data set to assess and reduce the impact of observer biases, and the ecological equivalency of certain pollen taxa, I have “filtered” the raw data base to produce one I consider more likely to be interpretable in archaeologically meaningful terms. These are the modifications I have made and the reasons therefore:

#### MODIFICATIONS OF THE RAW DATA BASE

- (1) The raw data base incorporates four morphologically similar, but distinguishable, vesiculate pollen taxa: *Picea*, *Abies*, *Pinus ponderosa* -type and *Pinus edulis* -type. Though they are usually differentiated in Colorado Plateau pollen studies, I think the range of ways in which they are preserved in these samples and the potential for observer biases among the students, calls for conservatism. I have grouped all observations of these taxa into the single category, Pinaceae.
- (2) The raw data base incorporates two morphologically similar, but distinguishable, inaperturate pollen taxa: *Cupressus* and *Juniperus*. The former taxon was rarely reported observed in statistically significant amounts, but where so reported I suspect it was either misidentified *Juniperus* or locally overrepresented. By grouping observations for both pollen taxa in one category, the effects of either sort of error on interpretation have been reduced. *Quercus* pollen was never recorded in statistically significant

quantities. Since it seems to me more likely that the oak pollen observed was produced in the plant associations in which juniper pollen was produced, I have included the *Quercus* observations in a *Juniperus+Cupressus+Quercus* pollen category.

(3) The raw data base differentiates “lo-spine” (Ambrosieae) from “hi-spine” (Tubuliflorae) forms of Compositae family pollen. I suspect different observers adopted somewhat different standards for separation of the two pollen types, so I have reduced errors that may have been induced by observer bias by collapsing both types into one category: Compositae.

(4) The “unidentifiable pollen” taxon (not surprisingly) was particularly overused by some observers as they were becoming accustomed to the difference between better and more poorly preserved pollen, early in the period of skill development in pollen identification. To reduce variability in observer biases, I have excluded this taxon from the pollen sum upon which relative frequency values are calculated.

(5) The pollen record provided for sample 68North 82East, 70-80 cm depth has been excluded from the analysis because it yielded only a small pollen count with a high proportion of unidentifiable pollen. I have also excluded the 0-10 cm samples from the analysis. Most often, students were directed to use the samples collected at 0-10cm depth for their first attempts at fossil pollen observation. After subsequent work, one student acknowledged that the pollen record resulting from his first effort was not trustworthy and should not be included in the raw data base. Considering the variability in observations for these samples recorded by different students, I consider the others untrustworthy as well.

(6) In all other cases where multiple observers independently studied pollen drawn

from the same sample, I have utilized the mean relative pollen frequency in my analyses, based on the pollen sum of the combined observations.

(7) *Zea* pollen is locally overrepresented in the sample collected at 84North 84East, 40-50 cm depth. I excluded *Zea* from the pollen sum of this sample to reduce the effect of its mathematical constraint on all other frequency values.

(8) *Rumex* pollen is produced by a plant which has become naturalized to the Colorado Plateau from Europe in historic times. As I doubt it has been properly identified I have included it in the "Unknowns" pollen taxon in my analysis.

(9) In my opinion, the observer identified by the initials CJM tended to do incomplete and inadequate work and failed to respond well to instruction or supervision. I have rejected all information he contributed to the raw data base from the analysis.

. The archaeological pollen analysis is thus based upon pollen records of 22 of the 32 samples originally selected for study.

## CATEGORIES OF THE POLLEN ANALYSIS

Colorado Plateau pollen studies are traditionally structured by the plant taxonomic categories (e.g. *Pinus*, *Juniperus*, *Betula*, Gramineae) and pollen morphology categories (e.g. Cheno-am, Lo-spine Compositae) used for recording observations. I abjure that approach in this work because of the character of the secondary purpose of the research. What we hoped to learn was whether patterns of palynological data displayed the sorts of horizontal or vertical variability that suggested they could support and inform archaeological interpretation. Given those interests, I believe the focus of analysis should be on the relative frequency values of palynological categories that express ecosystem and habitat variations, or express processes of



pollen production or pollen dispersal that are likely to have been affected by cultural activities. Analyses structured in terms of pollen types and pollen taxa are traditionally employed because they provide solid grounds for the sorts of paleovegetation reconstructions that identify the “environmental contexts” in which prehistoric cultural activities were embedded. While that would not be an unreasonable goal, I have structured this analysis to provide more conservative grounds for interpretations of sequential ecosystem changes that might have significantly affected the economic strategies of populations occupying the site at different times, and to identify indices of cultural activities.

Four categories of the analysis, CULTIVARS, RIPARIAN NAP, ZOOPHILOUS NAP and CHENO-AM, index cultural activities of various sorts. More precisely, statistically significant vertical or horizontal variation in the relative frequency values of these palynological categories are probably best interpreted as responses to cultural activities occurring at AZ22822. The only CULTIVARS pollen type observed in these samples, *Zea* pollen, is produced by an obligate cultivar which cannot exist in a wild state. Recovery of its pollen in archaeological site context deposits is therefore most appropriately attributed to cultural activity. The pollen types of the RIPARIAN NAP (*Polygonum*, Cyperaceae and *Typha*) and ZOOPHILOUS NAP (Cruciferae, Umbelliferae, Leguminosae-type, *Oenothera*, *Sphaeralcea*, and Nyctaginaceae) categories are either naturally dispersed in very small quantities or are produced by plants whose ecological requirements obviate growth on this sort of substrate or in the immediate environs of this site. As a result, natural processes of pollen dispersal and preservation are less likely to account for significant variability in pollen frequencies than

cultural activities.

The morphological pollen type identified as CHENO-AM pollen is produced and dispersed in large quantities by members of a number of genera in the Chenopodiaceae family and by species of the genus *Amaranthus* in the Amaranaceae family. Species which produce this sort of pollen are adapted to survive in a wide range of different ecosystems and habitats throughout the world. Hall's (1985) review of Quaternary and Holocene pollen records from the American Southwest provides abundant evidence that frequency values for this pollen taxon are interpreted distinctively by various workers, and it is not unlikely that Cheno-am pollen frequency values index different sorts of ecosystem conditions in different places and at different times. However, many of the species that produce Cheno-am pollen are pioneer, ruderal or halophyte taxa that establish large populations at locales where human occupation or activity creates disturbed and highly mineralized ground surfaces. Since the deposits sampled for pollen at AZ22822 were collected at a locus of human behavior, the depositional contexts of their pollen records suggests variability in Cheno-am relative frequency values is at least as likely to be a response to human behavior patterns as any alternative. Lacking evidence to the contrary, I consider variability in the relative frequency of Cheno-am pollen (either horizontally or vertically) most likely to index the intensity and consistency of behavior patterns producing local disturbed ground habitats

Three palynological categories, COMPOSITAE, SHRUBS and GRAMINEAE +, index different sorts of open or understory conditions of the site-specific ecosystem. The pollen types grouped in the COMPOSITAE category (the lo-spine pollen attributable to species of Ambrosieae and the hi-spine pollen attributable to species of

Tubuliflorae) are produced by plants relegated to two of the numerous subfamilies of this very large plant family. Many more individual plants of Tubuliflorae genera and species exist within Colorado Plateau ecosystems, but most produce much less pollen than individuals of the Ambrosieae group and disperse it much less widely. Though they are not the most common Compositae of the area, numerous individuals of shrubby Compositae genera such as *Chrysothamnus* and *Gutierrezia* have adapted quite effectively to grazed and overgrazed landscapes in the region over the past century and today serve as excellent indices of sediment surfaces heavily impacted by conditions that interrupt the normal processes of soil formation and plant succession. I believe statistically significant horizontal variation in the COMPOSITAE category probably is best interpreted as evidence of local overrepresentation of Tubuliflorae shrubs growing at the sampling locus, but significant vertical variability should be interpreted as evidence of the effects of conditions (either natural or cultural) leading to general destabilization of the dune's surface.

Most of the pollen types of the SHRUBS category (*Yucca*, *Cylindropuntia*, *Artemisia tridentata*, *Ephedra nevadensis*-type and *Ephedra torreyana* -type) are produced by plants which tend to occur as occasional individuals in open grassland and savannah habitats. The dune substrate of AZ22822 cannot accommodate stands of these shrubby taxa today, and could only have done so in the past if climatic conditions were very different. The remaining pollen types of this category, *Ribes* and *Rhus*, are produced by shrubs typically found at woodland margins where soils are rich and light levels are higher than is normal in the woodland understory. They may occur today near AZ22822 in or marginal to the riparian flora along Chevelon Creek, but are not well

adapted for survival on dune deposits. A significant increase in the pollen frequency value for this category, then, would constitute sufficient evidence for major changes in the characteristics of local ecosystem conditions to support hypotheses of coincident transformation of the economy of the site's occupants..

The GRAMINEAE + palynological category pollen types (Gramineae, *Artemisia frigida*-type and *Artemisia* undifferentiated) are produced abundantly and dispersed widely by plants adapted to open and savannah habitats on the Colorado Plateau. Horizontal variability in frequency values for this category is likely to be strongly normalized because of these processes, and diachronic variability more likely to be a response to significant changes in the relative frequency values for other palynological categories than a direct index of ecosystem modifications. Significant increases in the SHRUBS or the ZEA pollen frequency values, for example, suggesting modifications of local ecosystem or behavior patterns, would be more likely to be responsible for coincident significant decrease in the GRAMINEAE + category values than any actual reduction in the quantity of grass pollen produced and dispersed at the site.

The PINACEAE, JUNIPERUS+CUPRESSUS+QUERCUS and RIPARIAN AP categories incorporate pollen produced by trees of the forests and woodlands of the Colorado Plateau. As explained earlier, pollen types included in PINACEAE (*Abies*, *Picea*, *Pinus ponderosa*-type and *Pinus edulis*-type) are produced by trees typical of distinctive plant communities and ecosystem conditions. Here they are considered as a group because of the possibility that the identifications are otherwise untrustworthy. As a group they reflect ecosystem conditions that affect the overcanopy trees of Colorado Plateau forests. Thus significant horizontal variability in the relative pollen frequency for

this category should not occur, and if it does occur it identifies strong evidence that archaeological interpretation of the data base is not justified. If analysis demonstrates that samples likely to contain contemporary pollen records from different parts of the site yield statistically comparable PINACEAE relative frequency values, however, diachronic variability in such values identifies strong evidence for ecosystem changes in the site environs that probably had significant effects on the economic activities of its occupants.

Pollen frequency values for the JUNIPERUS+CUPRESSUS+QUERCUS category identify pollen productivity by undercanopy, open woodland and savannah trees which, like the overcanopy trees, generate abundant pollen and disperse it quite widely. Horizontal variability in the relative frequency value for this category could, then, suggest interpretation of the data base is unwise. However, at a site such as AZ22822, pollen production by understory arboreal taxa is likely to be relatively less than pollen production by shorter-lived plants responding to the temporary occurrence of unusual edaphic or weather conditions. Horizontal variability in the relative frequency value for this category, then, may be a product of locally overrepresented values in the COMPOSITAE, CHENO-AM or GRAMINEAE categories, or horizontal variations in the palynological categories reflecting human behavior patterns. Where that is not the case, vertical variability in this category should be inversely related to vertical variability in the PINACEAE category.

Statistically significant vertical variability in the RIPARIAN AP pollen category could be interpreted in one of two ways. If it occurs concurrent with variation in the RIPARIAN NAP category, it is probably best interpreted as a consequence of human

activities that brought riparian community plant resources to the site proper. If not, it may suggest modifications of the plant community adjacent to Chevelon Creek created by hydrographic changes, such as downcutting or alluviation. Statistically significant variations in the UNKNOWNNS palynological category should not occur. If it does, such variations would strongly suggest that unrecognized errors in the data base affect the analysis. The UNKNOWNNS category is included in the analysis principally as means of recognizing whether or not such errors occur.

## RESULTS OF THE ANALYSIS

### *Horizontal Variability*

Since the samples from the 0-10cm level were excluded from the analysis, the series of samples most likely to have been deposited at approximately the same time on different parts of the site are those collected from the basal sand deposits at 84North 84East (40-50cm), 86North 89East (50-60cm) and 92North 102East (70-80cm). These samples yield statistically comparable values for PINACEAE and GRAMINEAE + pollen. Unexpectedly low values in the JUNIPERUS+ CUPRESSUS+ QUERCUS pollen category in two of these samples are compensated by local overrepresentations in the CHENO-AM and the RIPARIAN AP categories.

Other records that suggest that samples deposited at the same time at different parts of the site yield comparable relative pollen frequencies derive from the samples collected at 82North 120East (10-20cm) and 70North 70East (30-40cm) which are associated with artifactual evidence of earlier occupation at the site and a stratigraphically early midden, respectively, and comparable relative pollen frequency values for samples collected from the hearth and the lower fill of a pitfeature associated

with the same pithouse [samples 101North 60East(40-50cm) and 105North 60East(40-50cm)].

In short, a body of positive evidence exists that argues that such horizontal variability as exists in pollen records from the site is explicable as the expectable result of local overrepresentation of pollen types by plants adapted to niche differences of the sort that occur on the site today, and no evidence exists that suggests otherwise.

### *Vertical Variability*

Vertical variability in the pollen frequencies of the categories is most clearly expressed by the Table 1, which shows the pollen frequency values for samples recovered in stratigraphically superimposed order. The sample sequences collected at 84North 84East, 88North 89East and 92North 102East were submitted specifically to test for vertical variability<sup>1</sup>. Stratigraphically superimposed samples were also submitted from loci 70North 70East, 48North 60East and 105North 60East, and their pollen frequencies are also included on this table.

The pollen frequency values of the 0-10cm and 20-30cm depth samples from 84North 84East are statistically equivalent, but the values for PINACEAE, RIPARIAN AP, and COMPOSITAE are sufficiently distinct that the 40-50cm sample cannot be a member of the same sample population. In the case of the samples from 86North 89East, the pollen frequency values for the 40-50cm and 50-60cm samples are statistically equivalent, but the values for JUNIPERUS+CUPRESSUS+QUERCUS and

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<sup>1</sup> Samples also were submitted from locus 68North 82East, but only one of that suite of four samples yielded sufficient pollen for analysis.

Table 1

SQUARE	DEPTH	PINACEAE	JUNIPERUS+ CUPRESSUS+ QUERCUS	RIPARIAN AP	SHRUBS	GRAMINEAE +	COMPOSITAE	CHENO-AM	ZOOPHILOUS NAP	RIPARIAN NAP	UNKNOWN	CULTIVARS	N
84N84E	0-10cm	18	40	0.6	0.6	16.6	11.3	9.3					150
	20-30cm	23.7	30.1	1	5.5	14.8	14.5	13.2	2.1	2.7	0.6		379
	40-50cm	5.4	26.2	8.9	1.8	20.5	25	8.3	1.5	1.5	0.6	39 grains	336
86N89E	20-30cm	13	57.7		0.5	5	4	19	0.5	0.5			201
	40-50cm	12	20.7			23.6	21.6	22.1		1.9			208
	50-60cm	9.1	10.1	0.5		21.7	28.3	23.2	2				198
92N102E	20-30cm	16.3	29.7	6.8	2.4	4.9	24.8	14.2	0.3	0.5			367
	50-60cm	17	18.9		1.4	22.1	4.6	35.9					217
	70-80cm	3.5	46.2			28.6	7	12		2.5			199
70N70E	10-20cm	45.2	24.9	1	2.2	9.6	10.2	6.1		0.5			197
	30-40cm	71.6	10			3.5	4.5	8	0.5		1.5	0.5	201
48N60E	20-30cm	45.7	15.1	2.9		21.2	7.8	4.5	1.2		0.4	1.2	245
	30-40cm	33.2	22.8	1.3		20.3	8.8	12.2	0.8				394
105N60E	20-30cm	42.5	21.1	0.2	0.5	13.1	4.8	17.1	0.2	0.2	0.2		421
	40-50cm	29	19.5			16.7	9.7	25.6	0.8	0.2			390



COMPOSITAE pollen in the 20-30cm sample identifies it as a member of a distinctive population. Each of the samples of the 92North 102East series is statistically distinctive in some way: the 20-30cm sample has significantly lower GRAMINEAE + and significantly higher COMPOSITAE pollen frequency values than either of the other samples, and the 70-80cm pollen record has significantly lower PINACEAE and significantly higher JUNIPERUS+CUPRESSUS+QUERCUS values.

The vertical variation which occurs in the pollen frequency values of the superimposed samples from 48North 60East and 105North 60East is particularly informative, because the character of the stratigraphically superimposed variations is replicated at the two loci, which are horizontally separated by 57 meters. In both instances, the upper sample contains statistically more PINACEAE pollen and the lower sample contains statistically more COMPOSITAE pollen. In addition, the upper samples from each locality are members of the same statistical pollen record population and the lower samples are members of the same statistical pollen record population. This suggests that such vertical palynological variability as exists among the suite of samples collected from the site is patterned, and thus a response to modifications of ecosystem and/or cultural conditions occurring over the course of time. This suggestion is reinforced by both the fact that all available evidence argues that samples deposited at approximately the same time yield statistically comparable pollen frequency values (except where influenced by locally overrepresented pollen categories) and by the existence of suites of samples that form statistically segregable populations.

When the samples of these populations are arranged in a fashion consistent with their relative stratigraphic positions, they are arrayed as illustrated on the table titled

## *AZ22822 Pollen Sequence.*

### INTERPRETATIONS

(1) Vertical variability in relative pollen frequency values allows recognition of a minimum of seven chronological episodes. Material culture evidence of prehistoric occupation of the site is directly associated with the pollen records of five of these episodes, three of which also provide palynological evidence of cultural activity through recovery of maize pollen.

(2) The earliest episode of the sequence is identified from the pollen records of samples recovered from the basal deposits of the dune at or above the contact with the orange sand of the terrace. One of the samples deposited during this episode incorporates CULTIVARS pollen and RIPARIAN AP pollen at frequency values best interpreted as responses to local overrepresentation due to cultural activity. This data suggests occupation of the site from the earliest period of dune formation.

(3) The second oldest episode of the pollen sequence is associated with material culture attributed to a possibly early occupation deposit at 82North 120East (10-20cm; 2.26m above datum), the earlier of the superimposed midden deposits at 70North 70East (30-40cm; 0.13m above datum) and fill samples from the basal deposits of Pithouse 1 (102North 88East 20-30 and 30-40cm; 0.24m and 0.44m below datum). The deepest pithouse sample contains unusually high frequencies for RIPARIAN NAP and CHENO-AM pollen. The former suggests cultural activities related to riparian resources, in this instance the possible use of floor or sleeping mats woven of sedge; the latter suggests disturbed ground in the immediate environs of the structure. Wide

variability in the relative and absolute depths for these apparently contemporary samples suggests different areas of the terrace surface were blanketed by dune sands at different times. This, in turn, suggests that the small number of samples investigated in this study is unlikely to allow identification of the complete sequence of chronological episodes identifiable through palynological research at the site.

(4) PINACEAE pollen frequency values for samples of the second chronological episode are very much more elevated than those for samples of the earliest episode. Apparently, there was essentially no pollen production by upper canopy trees and relatively little by undercanopy trees at the site during the earliest episode. The site surface was probably mainly occupied by grasses and a significant number of shrubs adapted to somewhat disturbed ground. Pollen production by overcanopy trees was increased at least six-fold in the second episode, however, and pollen frequency values for other palynological categories commensurately reduced.

It is not clear that this sort of modification of the pollen record argues for the development of forest at the site, for Dean (1988:144-5) presents a cogent argument suggesting that equating elevated AP frequency values with an increase in numbers of trees results in a poorer relationship between dendrological and palynological evidence of rainfall variations than actually seems to exist. A major change in ecosystem conditions is evidenced, however, which is probably best interpreted as resulting in a cooler-wetter local environment conducive to development of a significant positive change in primary productivity at the site and within the general area, and probable stabilization of the site surface and initiation of a period of soil development and alluviation on the floodplains of Chevelon Creek and its tributaries.

Ecosystem changes of this order would expectably affect the organization, if not the character, of the economic behavior of residents of the site and the local area.

(5) The third episode of the chronology is the most weakly evidenced, and is principally distinguished from the sixth episode by lower JUNIPERUS+CUPRESSUS+QUERCUS pollen frequency values and higher values for the GRAMINEAE + and CHENO-AM categories. Palynological evidence for this episode has only been recovered from core sequence samples, so none is associated with evidence of site occupation. PINACEAE pollen frequency values for the samples of this episode are little elevated above those of the first episode, suggesting a drastic reduction in pollen production by overcanopy trees relative to the second episode, but JUNIPERUS+CUPRESSUS+QUERCUS values do not rise to the levels indicated in the first episode. Primary productivity seems to have been drastically reduced at the site and in the region at this time, the site itself may have been unoccupied, and vegetative coverage reduced to sparse grasses and a good deal of open, windswept, ground. The palynological record suggests an episode of active dune formation.

(6) The fourth and fifth palynological episodes are only distinguished by statistically significant differences in extreme frequency values for PINACEAE pollen (e.g. 29.0 vs. 45.7 per cent, and further work may suggest it would be judicious to recognize them as a single episode. The pollen record identifies increased pollen production by both overcanopy and undercanopy trees at the site. Presumably, this documents significantly increased levels of regional primary productivity that were most likely the product of increased effective moisture. Though lack of surface sample controls makes it unwise to interpret the palynological record in this way, my guess is that overcanopy

and undercanopy arboreal coverage at the site approximated that observable today.

Samples attributable to these episodes of the pollen sequence were directly associated with evidence of midden, hearth and pitfeature archaeology, though none were associated with the pithouse architectural units thought to represent the main period of site occupation. If the fourth and fifth episodes of the pollen sequence were of short duration, less than 100-125 years, they may identify a period when occupation at the site was not focussed on residency but on cultural activities performed during temporary camping episodes. On the other hand, if they were of significantly longer duration, say more than 150-200 years, it is more likely that habitation architecture of this period exists at the site but associated samples were not included in this analysis. In that case, the site's architectural record is likely to show a significant degree of stylistic modification, for site occupancy would then probably exceed a five hundred years duration.

(7) The sixth palynological episode is characterized by sharply elevated frequency values for the JUNIPERUS+CUPRESSUS+QUERCUS pollen category. Interestingly, both GRAMINEAE+ and COMPOSITAE pollen frequency values are reduced as well as PINACEAE values in samples representing this episode. The increase in pollen production by lower canopy trees suggests some sort of significant modification of the local ecosystem, but it is doubtful that regional ecosystem changes stimulating change in economic practices can be demonstrated for this episode without independent evidence from a number of sites.

(8) PINACEAE and JUNIPERUS+CUPRESSUS+QUERCUS pollen frequency values are both reduced in the seventh palynological episode and those for the

GRAMINEAE + and COMPOSITAE categories are increased. The differences between the seventh and sixth episode pollen records may be magnified by small numbers of samples, however, and both together may identify a continuing trend of ecosystem change rather than clearly separated episodes. The lower sample collected at Pithouse 3 and that collected in association with a possibly Historic Period archaeological record are both attributable to this palynological episode. One of these associations is likely to be erroneous.

## SUMMARY AND CONCLUSIONS

Palynological study of sediment samples recovered from AZ 22822 was undertaken primarily to provide students opportunity to develop skills in the methods and techniques of archaeological pollen analysis (*sensu* Schoenwetter, 1970). The number of students and scheduling constraints limited study to 32 samples, selected according to a strategy based upon information on gross geomorphic and archaeological characteristics of the site locality. One sample was lost through laboratory error and six failed to yield sufficient pollen for analysis. The original data based of pollen observed and identified by the students was thus generated through study of 25 samples, though a number of samples were independently observed by more than one student.

The original data base thus incorporated 42 independent pollen records, allowing evaluation of observer biases and errors resulting from inexperience. As an aspect of the course, the students made evaluations of these sorts, and the original data base was modified accordingly. The “raw data” tabulation submitted with this report, and the observation sheets that comprise the permanent laboratory record, identifies the data

base the student observers consider sufficiently trustworthy for analysis.

No body of palynological data is invariably free from other sorts of errors, however, and normal practice recognizes that errors induced by local overrepresentation, long distance pollen transport, vertical pollen transport during soil formation, problematical identifications and the effect of chance on pollen statistics should be recognized and reduced as an aspect of analysis. Here, a suite of manipulations of the raw data base were performed for this purpose prior to analysis. For example, pollen records I considered untrustworthy were excluded from the analysis; independent observations of the same sample were combined into a single pollen record to reduce observer bias; and a number of morphologically similar pollen types were collapsed into a single pollen taxon to reduce the affect of possible misidentifications on interpretation. This sort of data filtering resulted in acceptance of the pollen records of 22 samples for analysis.

Analysis of the “filtered” data base was undertaken in terms of palynological categories distinct from those traditional to archaeological pollen studies on the Colorado Plateau. Analyses are normally performed in terms of palynological categories that reference distinct plant species, genera or families (e.g. *Pinus ponderosa*-type, *Quercus*, Gramineae) or pollen types whose morphology allows identification in plant taxonomic terms (e.g. Cheno-am, Tubuliflorae). These categories are appropriate to analyses whose immediate objective is identification of the vegetation pattern, plant community or plant resources represented by the pollen records, and whose ultimate objective is reconstruction of the paleoenvironmental context of associated archaeological information (Environmental Archaeology *sensu* Shackley

1981) and/or identification of ethnobotanical resources. The archaeological objectives of this study were more limited because (1) the few samples that could be investigated would not satisfactorily represent all likely site occupations, and (2) the limited range of subsurface archaeological evidence provides no opportunity for controlled interpretation of the chronometry of probable sequential site occupations.. The objectives of this analysis were to determine the likely degree of horizontally and vertically organized patterned variation in site-context pollen records, to assess the likelihood that ecosystem conditions at the site had undergone sufficient modifications that economic activities might have been disrupted, and to determine whether or not some of the range of cultural behaviors that occurred at the site were expressed in the palynological record.

Horizontal variability in the palynological record (that is, the amount of similarity or dissimilarity that occurs among samples likely to have trapped pollen in different areas of the site at the same time) is a measure of the degree to which pollen spectra of ostensibly equivalent antiquity monitor indices of pollen production in the same fashion. Precise replication is not expected of such spectra because highly localized factors that affect the ways pollen is distributed and preserved can impact the relative pollen frequency values which serve as the basis for comparison. If statistically significant differences among the relative pollen frequency values of the samples can be accounted for on such grounds, however, and if similarities among suites of ostensibly contemporary samples are satisfactorily accounted for as statistically equivalent indices of site-scale conditions, interpretations of the archaeological implications of the pollen frequencies are justified.

Suites of samples that have been recovered in stratigraphic order from the same



part of an archaeological site provide evidence for the occurrence of vertically patterned variations in the site's pollen record. These results may be independently buttressed by palynological records directly associated with archaeological evidence of site occupations at different times, using the assumption that the artifacts and associated pollen were incorporated into the sampled site-context deposits at the same time. Site-wide patterns of vertical variation in pollen frequency values express a pollen sequence for the site, which identifies episodes of time during which environmental conditions or cultural activities influenced the pollen record in characteristic ways. Though the relative temporal order of such episodes can be inferred from the relative stratigraphic positions of the samples, the durations of the episodes and their absolute temporal positions must be inferred from associated chronometric information. Also, the number of palynologically evidenced episodes for a site cannot be greater than one-half the number of analyzed samples, since no fewer than two statistically comparable samples are required to identify an episode. When, as in this case, the site's formation is likely to have occurred over the course of several millennia, the pollen sequence that can be revealed by less than two dozen pollen records is likely to be far from complete, and the amount of palynological evidence for any given episode is likely to be less than fully satisfactory.

Given the limited number of samples, and our interest in determining whether further palynological research at the site would be of sufficient archaeological value to justify substantial investment, it was appropriate to perform the analysis in conservative fashion. That is, to undertake the analysis in a way which would identify statistically robust patterns of horizontal and vertical variability in pollen frequency values. Only

then could we aver that these variations were clear indices of two matters of major archaeological interest: the character of local and regional ecosystem conditions likely to have affected economic activities of the site's occupants, and the character of palynological evidence that suggested paleoethnobotanical behaviors -- including human impacts on the site landscape. Accordingly, analysis proceeded through calculation of relative pollen frequency values of only eleven palynological categories. Four categories (CULTIVARS, RIPARIAN NAP, ZOOPHILOUS NAP and CHENO-AM) identify relative pollen frequency values which would expectably vary as a result of cultural activities; three categories (COMPOSITAE, GRAMINEAE + and SHRUBS) identify relative pollen frequency values which would expectably vary in response to ecosystem conditions that prompt distinctive adaptations by localized ground cover vegetation; and three categories (RIPARIAN AP, JUNIPERUS+ CUPRESSUS+ QUERCUS and PINACEAE) identify relative pollen frequency values for which statistically significant variation would index ecosystem conditions affecting floodplains, underconopy woods and overcanopy forests, respectively.

Organizing the filtered data set in this fashion allowed an analysis which produced statistically robust evidence that horizontal variability does not influence the site's palynological record. Statistically robust vertical variation occurs, however, and is patterned in the fashion which suggests that the site's pollen records identify a sequence of at least seven palynological episodes. Changes in both ecosystem conditions and cultural activities can be identified by changes in pollen frequency values over the period of site formation and successive occupations.

Palynological evidence of maize cultivation occurs in the form of maize pollen

grains in four of the analyzed samples. Two samples were directly associated with archaeological evidence of site occupation (the earlier midden at 70North 70East and the hearth feature at 48North 60East); one seems likely to represent the same episode of site occupation as Pithouse 2; and one was recovered from deposits likely to represent the earliest period of dune formation at the site. Maize pollen is significantly overrepresented in this last sample, suggesting a different sort of cultural behavior than that responsible for the occurrence of maize pollen in the other samples.

Statistically significant variation does not occur amongst the samples in the ZOOPHILOUS NAP pollen category, but is expressed in both the RIPARIAN NAP and the CHENO-AM categories. The single statistically significant increase in the frequency value of RIPARIAN NAP pollen is associated with the floor deposit of Pithouse 1, and suggests use of sedges for floor or sleeping mats. Significantly elevated CHENO-AM pollen frequency values in samples associated with Pithouse 1 and an earlier midden deposit suggest intensification of localized human disturbance of the site surface. Significantly reduced CHENO-AM pollen frequency values are associated with the upper fill of a hearthfeature and the artifacts of a later midden. They suggest an unusually low degree of human impact for the site, so imply the potential of future pollen studies to provide evidence of episodes of greater and lesser intensity of site occupation. Significantly higher CHENO-AM pollen frequency values also are observed in samples of the third episode of the site's pollen sequence, when other palynological indices of desertification and active aeolian erosion also occur.

Five statistically significant changes occur in the frequency values for pollen categories that index ecosystem conditions over the course of the pollen sequence.

The earliest suggests a change from minimal levels of primary productivity when dune and site formation began to maximal levels by the time occupation deposits were laid down at 70North 70East, 82North 120East and Pithouse 1. Ecosystem modification of this magnitude is likely to have been of regional scale, and would expectably stimulate change in the organization, if not the character, of the economies of local human populations. Palynological evidence of maize production occurs prior to as well as subsequent to this change in ecosystem conditions.

Primary productivity was then reduced nearly to its former level, and the frequency values for SHRUBS, GRAMINEAE+, COMPOSITAE and CHENO-AM pollen suggest this third episode of the pollen sequence witnessed intensification of process of desertification and active aeolian erosion. Palynological indices of primary productivity values were again elevated in the fourth and fifth episodes of the pollen sequence, but to significantly less degree than during the second episode. It seems not unlikely that the two episodes identify a trend that culminated in the establishment of local and regional primary productivity levels comparable to those that occur today, though controlled evidence for this conclusion is yet to be developed. These episodes of the pollen sequence are represented in sediment samples associated with a range of non-architectural features, and may identify the site's principal occupation horizon. If so, it is critical that chronometric evidence of the duration of these episodes be developed, for the study of processual culture change will be affected quite differently if the episodes encompass a short or a long period of time.

Ecosystem conditions were again changed by the time records of the sixth episode of the pollen sequence were laid down. At present, it is unclear if the

modification involved was of regional or local scale, or if it identifies a difference in primary productivity or only a difference in the way primary productivity came to be expressed palynologically. If the latter, this ecosystem change may have been induced as a product of human impact and cultural behavior. It may be no coincidence that pollen records of the sixth and seventh episodes of the pollen sequence are associated with the basal deposits in-filling Pithouses 2 and 3. If residential use of the site was intensified at this time, a reduction of pollen production by overcanopy trees and a compensating increase in pollen production by undercanopy trees could reflect behaviors oriented towards lumber harvesting and the conservation of more easily managed fuel resources.

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